sustainability symposium

Carrier
United Technologies
turn to the experts

Energy Modeling for the LEED® Energy & Atmosphere Credit 1

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Regional Sales Manager
Software Systems

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EDUCATION AND CREDENTIAL CREDITS

In order to receive a certificate for this course you must both:

1. **Sign the workshop attendance sheet which demonstrates that you have attended the workshop**
   This will be passed around the room at the start of the workshop.
   Print legibly so that information can be easily verified.
2. **Complete the Survey**
   At the end of the workshop, you must also complete the workshop evaluation.

Turn in the Evaluation to the moderator.
Certificates will be sent to you.

Under the November 2012 rule, this course may qualify for GBCI LEED CMP credit under the Educational Category

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SESSION OBJECTIVES

After this session you should be able to:

1. Identify the key prerequisites for high quality energy modeling and the risks created by failing to meet each prerequisite
2. Explain how the ASHRAE 90.1 Appendix G Performance Rating Method determines energy cost savings for a building project, and how the cost savings are used to calculate LEED® Energy and Atmosphere Credit 1 points
3. State the basic principles used to assemble the Baseline Building for a given proposed Design in a LEED® Energy and Atmosphere Credit 1 analysis
4. Describe how to evaluate thermal block modeling issues in a building to minimize modeling cost and at the same time preserve accuracy of results

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SURVEY

LEED and Energy Modeling

Does your firm or organization:

1. Participate in LEED® projects?
2. Perform energy modeling?
3. Perform energy modeling for LEED® projects?

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AGENDA

A. Introduction

1. Brief overview of LEED® rating system
2. Energy modeling and applications
3. Key conditions for high quality energy modeling

B. Energy Modeling for LEED EA Credit 1

1. Overview of Performance Rating Method
2. Alternate approaches to LEED® EA Credit 1 analysis
3. How an efficient approach works, step-by-step.
4. Software productivity features

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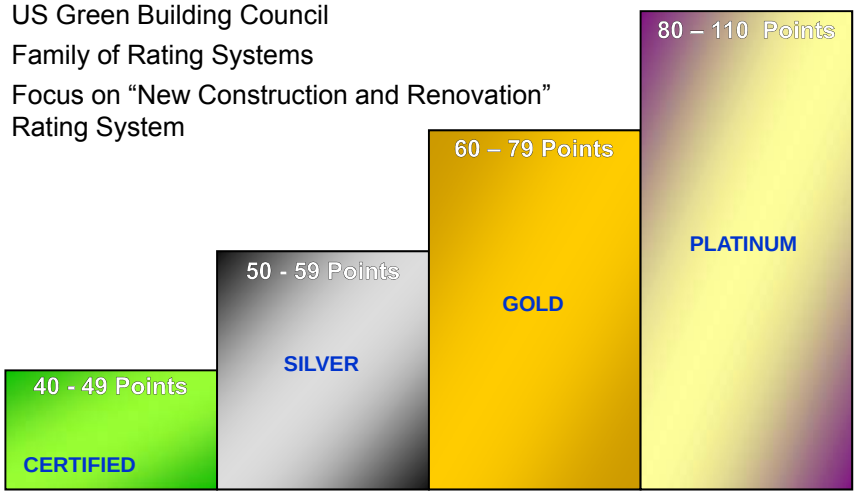
LEED® 2009 OVERVIEW

LEED = **L**eadership in **E**nergy and **E**nvironmental **D**esign

US Green Building Council

Family of Rating Systems

Focus on "New Construction and Renovation" Rating System



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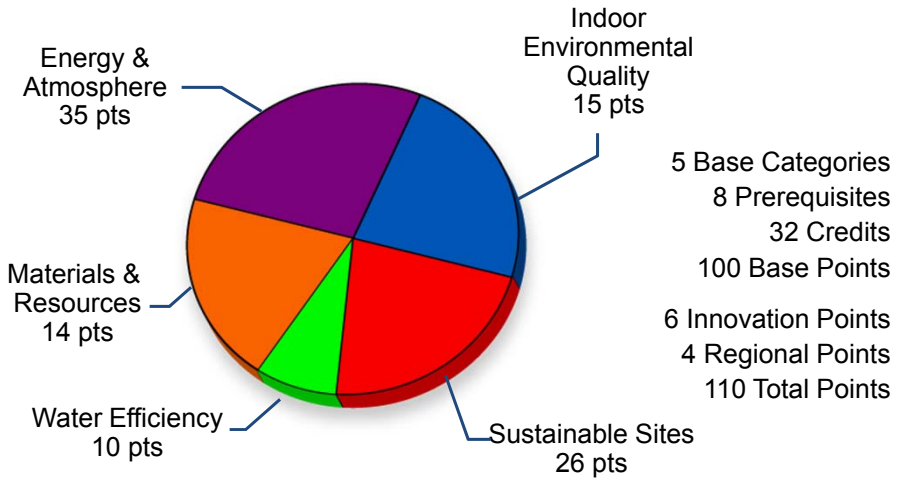
LEED® 2009 OVERVIEW

LEED® 2009 New Construction and Renovation


Energy & Atmosphere 35 pts
Indoor Environmental Quality 15 pts
Materials & Resources 14 pts
Water Efficiency 10 pts
Sustainable Sites 26 pts

5 Base Categories
8 Prerequisites
32 Credits
100 Base Points

6 Innovation Points
4 Regional Points
110 Total Points

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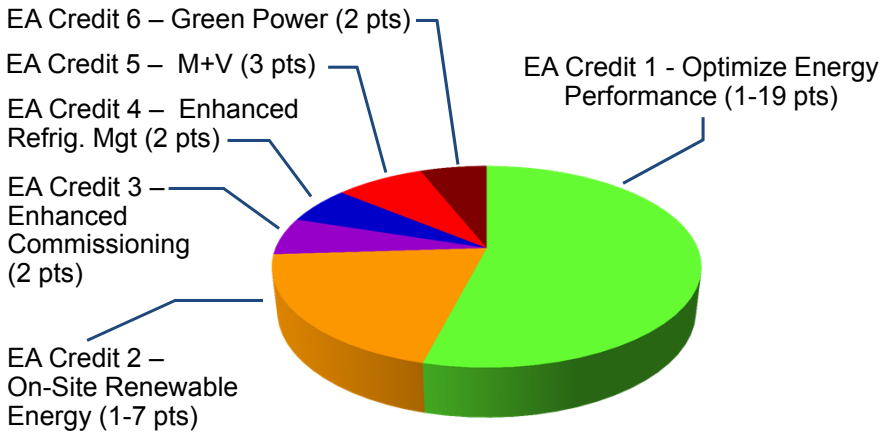
LEED® 2009 OVERVIEW


EA Credit 6 – Green Power (2 pts)
EA Credit 5 – M+V (3 pts)
EA Credit 4 – Enhanced Refrig. Mgt (2 pts)
EA Credit 3 – Enhanced Commissioning (2 pts)
EA Credit 2 – On-Site Renewable Energy (1-7 pts)
EA Credit 1 - Optimize Energy Performance (1-19 pts)

Energy and Atmosphere Category

3 Prerequisites
6 Credits
35 Credit Points

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LEED® 2009 OVERVIEW

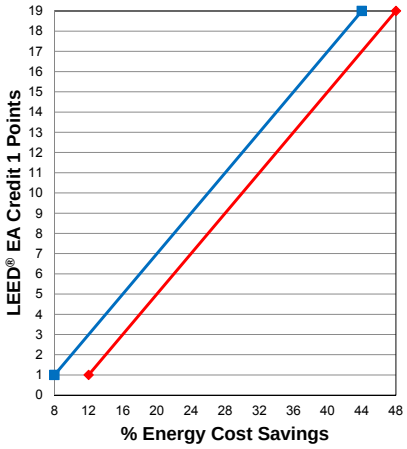
EA Credit 1 – Energy Modeling Approach

Earn 1 to 19 pts based on energy cost savings

Different scales for New Construction and Renovation

Existing Bldg Renovation:

8% = 1pt
to
44% = 19 pts



New Construction:

12% = 1pt
to
48% = 19 pts

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ENERGY MODELING

Alternate Terms

Energy Modeling
Energy Simulation
Energy Analysis
Energy Estimating
Opcost Analysis

Definition

Classical Energy Modeling - Creating a computer model of a building and its systems to predict annual energy consumption.

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ENERGY MODELING

Original Applications (1960s-Present)

- Schematic Design – Screening alternatives
- Detailed Design – Selection, optimization of design

Recent Applications (2000-Present)

- LEED® EA Credit 1, Prerequisite 2
- ASHRAE 90.1 Energy Cost Budget
- EPACT 2005 Energy Efficient Commercial Building Tax Deduction

Future Applications (Beyond 2010)

- ASHRAE Standard 189.1-2009
- ASHRAE EQ Building Labeling Program

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ENERGY MODELING

Key Conditions for High Quality Modeling

1. **The Energy Modeling Tool**
   - Appropriate, robust tool matched to objectives
2. **The Energy Modeler**

Proficient with:

- HVAC engineering fundamentals
- Chosen energy modeling software
- Procedure required to achieve objective

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QUESTION #1

Select (circle) the 3 items which are key conditions necessary for high quality energy modeling:

Energy modeling software:

a. Must use an 8760 hour-by-hour analysis.

b. Must be sufficiently detailed and have features capable of supporting your modeling objectives.

c. Must be capable of modeling at least 10 thermal zones.

Energy modeler:

d. Must be a LEED accredited professional.

e. Must understand the required energy modeling procedure.

f. Must be an accredited Building Energy Modeling Professional (BEMP)

g. Must understand the chosen energy modeling software operation, features, calculations, reports.

h. Must hold a BS degree or higher in engineering and have at least 5 years experience in HVAC engineering.

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PERFORMANCE RATING METHOD

Energy Modeling Procedure for EA Credit 1

Performance Rating Method (PRM)

Rates energy efficiency of buildings which exceed energy code provisions

ASHRAE 90.1-2007 – Appendix G

Requirements for:

Software Tool Used

Modeling Proposed Building

Modeling Baseline Building

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PERFORMANCE RATING METHOD

PRM – Basic Concepts

Basic Concept

Compare Proposed Design vs. Reference Case to determine energy cost savings

Savings Calculation

$$\% \text{ Savings} = 100 \times \frac{(\text{Baseline Energy Cost}) - (\text{Proposed Energy Cost})}{(\text{Baseline Energy Cost})}$$

All end uses for energy included

% Savings translates into LEED® credit points

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PERFORMANCE RATING METHOD

Proposed Building

Key Principles

- A version of designed building; not the actual building
- Modifications made to comply with PRM rules
- Energy cost **not necessarily** the actual cost for design

Example Modifications Required

- Conditioned spaces must be heated and cooled – even when actual is heating-only or cooling-only
- HVAC fans run continuously for occupied periods
- Manually operated shades not modeled

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PERFORMANCE RATING METHOD

Baseline Building - Basics

Key Principles

Baseline = Minimum prescriptive

As if building only designed to meet minimum code requirements

Prescriptive = ASHRAE 90.1-2007 Sections 5.5, 6.5, 7.5, 9.5/9.6.

Key Characteristics

Same size, shape, usage, # floors, site as Proposed

Walls, roofs, floors: prescriptive performance

Fenestration: prescriptive performance

HVAC, SHW: prescriptive requirements and min eqpt efficiency

Lighting: prescriptive lighting power density

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PERFORMANCE RATING METHOD

Baseline Building - Application

Model Baseline 4 Times:

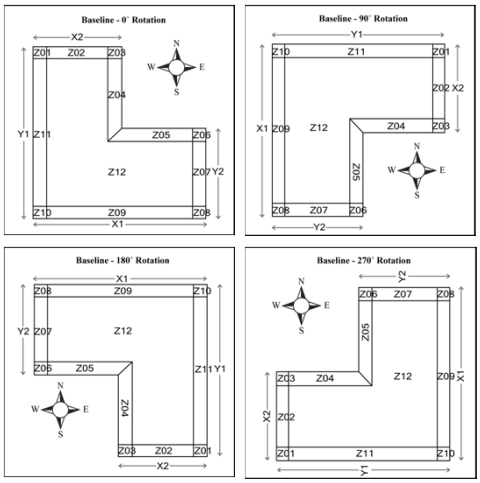
Actual orientation
Rotated 90° clockwise
Rotated 180° clockwise
Rotated 270° clockwise

Baseline Energy Cost:

Determine each Baseline energy cost

Compute average of 4 Baseline costs

Use average to determine % savings



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QUESTION #2

For a new construction project, if the PRM energy cost savings is 21.2%, how many LEED® EA Credit 1 points would be earned?

Points Earned = 5 pts

New Construction	
Energy Cost Savings	LEED EAc1 Points
12%	1
14%	2
16%	3
18%	4
20%	5
22%	6
24%	7
26%	8
28%	9
30%	10
32%	11
34%	12
36%	13
38%	14
40%	15
42%	16
44%	17
46%	18
47%	19

Existing Building Major Renovation or Addition	
Energy Cost Savings	LEED EAc1 Points
8%	1
10%	2
12%	3
14%	4
16%	5
18%	6
20%	7
22%	8
24%	9
26%	10
28%	11
30%	12
32%	13
34%	14
36%	15
38%	16
40%	17
42%	18
44%	19

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ANALYSIS APPROACH

Just-Do-It	Plan-Then-Execute
1. Brute force approach	1. Finesse approach
2. Enter data, run calculations, review results	2. Carefully plan and organize analysis per PRM rules
3. Figure out analysis as you go	3. Enter data, run calculations, review results

Risks:		Benefits:
More Time	Entering Data	Less Time
More Time	Running Calcs	Less Time
More Time	Troubleshooting	Less Time
More Time	Optimizing	Less Time
More Time	Documenting	Less Time
More Time	Review Questions	Less Time

Time = $$

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PLAN-THEN-EXECUTE APPROACH

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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CHOOSE SOFTWARE

Plan-Then-Execute Method

1. **Choose software**
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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SOFTWARE SELECTION

PRM - Minimum Software Requirements

Basic

- Computer based program
- Approved by rating authority
- 8,760 hours per year analysis
- Model proposed bldg features and/or can use exceptional calculation
- Model baseline bldg features
- Determine proposed and baseline energy costs, or supply energy use

Thermal Load Modeling

- Model hourly variations of internal loads, setpoints, HVAC operation, all days of week
- Model thermal mass effects
- Model ten or more thermal zones

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SOFTWARE SELECTION

PRM - Minimum Software Requirements

Equipment Modeling

- Model capacity + efficiency corrections curves for equipment
- Model part-load performance curves for equipment
- Model air-side economizers with integrated control

System Design

- Perform design calculations to size HVAC equipment capacity, air flow, water flow

Software Testing

- Vendor to test per ASHRAE Standard 140 and make results available

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SOFTWARE SELECTION

Beyond Minimum Compliance

Additional Considerations:

1. Technical capabilities
2. LEED®-oriented features for efficiency
3. Ease of use
4. Technical support
5. Training
6. Cost

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DETERMINE SCOPE FOR ENERGY MODELING

Plan-Then-Execute Method

1. Choose software
2. **Determine scope for energy modeling**
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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SCOPE OF ENERGY MODEL

Basic Principles

Scope = How much of building is modeled

1. New Construction

Model whole building

2. Renovation or Addition to Existing Building

Model whole building

OR

Model only addition or portion being renovated (specific requirements)

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SCOPE OF ENERGY MODEL

Why Scope Matters

Advantages of Reduced Scope

Faster, cheaper modeling

Can affect LEED® EA Credit 1 points potential

Example:

Office building

30,000 sqft existing

10,000 sqft addition

	Model Whole Building	Model Addition Only
Modeled Floor Area	40,000 sqft	10,000 sqft
Energy Cost Savings	$5,000	$5,000
Baseline Energy Cost	$61,000	$17,000
% Savings	8.2%	29.4%
Points Earned	1 pt	**11 pts**

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SCOPE OF ENERGY MODEL

Conditions for Reduced Scope

(All conditions must be met)

1. Renovation or addition to existing building
2. HVAC systems completely separate in part modeled and not modeled
3. Little or no heat flow through separating partitions; similar setpoints and schedules
4. Flat energy prices or separate energy meter for renovation

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QUESTION #3

What is the required scope for the example below? Is it whole building or addition only?

Example:

(1) Existing office building, 4 floors, 64,000 sqft

(2) Addition of 18,000 sqft office space to be constructed

(3) Flat energy prices will be used in model

(4) HVAC for addition is hydronic fan coil units

(5) FCUs to be connected to existing CW and HW plants

Answer: **Whole Building**

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DETERMINE SPACE CLASSIFICATIONS

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. **Determine space classifications**
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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SPACE USE CLASSIFICATION

Importance

Can affect:

- Thermal block strategy
- Baseline system selection
- Lighting power density (Baseline and sometimes Proposed)
- Schedules (if actual not known)
- Occupant, receptacle, SHW loads (if actual not known)

Classification Rules

- Use Building Area method or Space-by-Space method
- Consistently apply throughout building
- Multi-Use Buildings – Can use different building usage types
- Usage Not Known - Choose “Office” type

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DETERMINE THERMAL BLOCK STRATEGY

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. **Determine thermal block strategy**
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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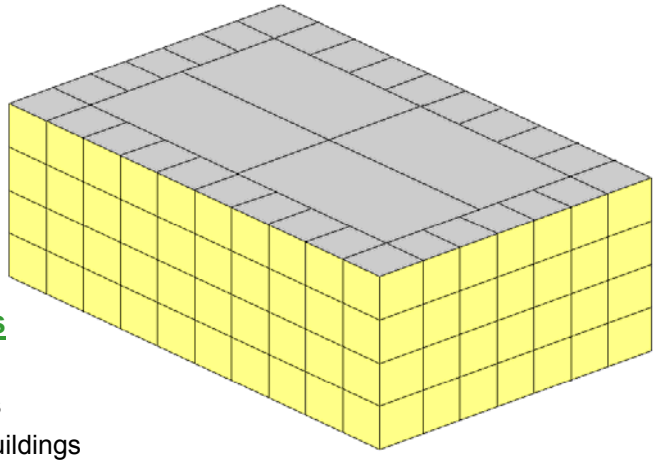
THERMAL BLOCKS

Example: Modeling Building As Designed

Conditions

Rectangular off
4 stories
60,000 sqft
152 zones



Consequences

1 Proposed Bldg
4 Baseline Bldgs
152 zones x 5 buildings
= **760 zones**

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THERMAL BLOCKS

Definition and Concepts

ASHRAE 90.1 Definition

Thermal Block – A collection of one or more HVAC zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

Concepts

Requires engineering judgment

Simplifies model without degrading accuracy

Key: Combine thermally similar zones into a single block

Thermally Similar Means…

Similar load density

Similar time-dependent behavior

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THERMAL BLOCKS

Basic Principles

Principles for Creating Thermal Blocks

Separate thermal blocks should be created for:

1. Zones with different building use or space use classifications
2. Ground floor, intermediate floors, top floor
3. Perimeter and interior areas
4. Zones with glazed exterior walls with orientation differing by >= 45°
5. Corner zones
6. Different or different kinds of HVAC systems

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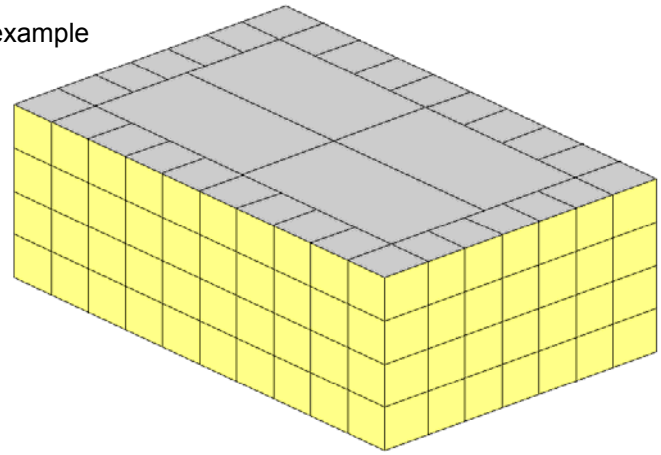
THERMAL BLOCKS

Application of Thermal Blocks

Conditions

Office building example



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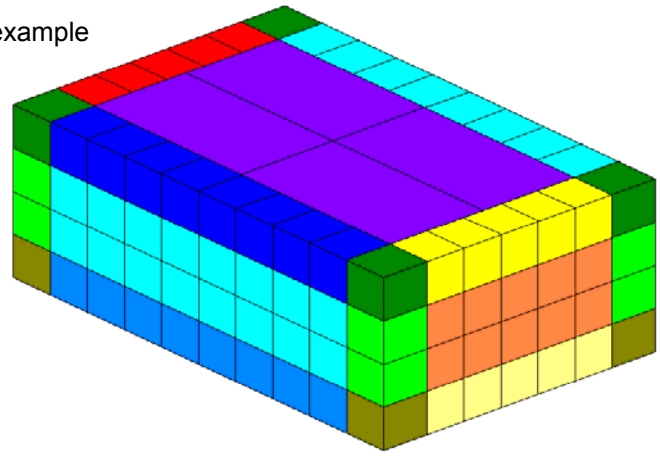
THERMAL BLOCKS

Application of Thermal Blocks

Conditions

Office building example



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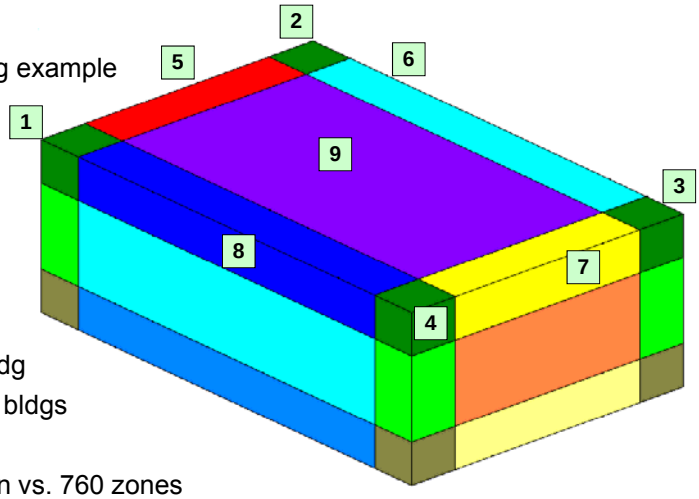
THERMAL BLOCKS

Application of Thermal Blocks

Conditions

Office building example



Benefits

27 blocks / bldg

27 blocks x 5 bldgs

= **135 blocks**

80% reduction vs. 760 zones

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THERMAL BLOCKS

Rules for Specific Scenarios

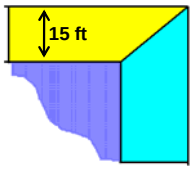
HVAC Zones Designed

1. Blocks are built from designed zones
2. Corners must be separate

1. Zones Designed - Corner Zones Separate

HVAC Zones Not Yet Designed

1. Construct hypothetical blocks
2. Perimeter and interior separate
3. Perimeter - 15 ft from exterior wall
4. Corners can be divided



2. Zones Not Designed - Corner Zones Divided

Multi-Family Residential

1. Blocks built from designed units
2. Corners must be separate

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QUESTION #4

For the sample building below use thermal block principles to reduce the number of thermal blocks (zones) modeled.

Minimum Blocks per Floor = _____

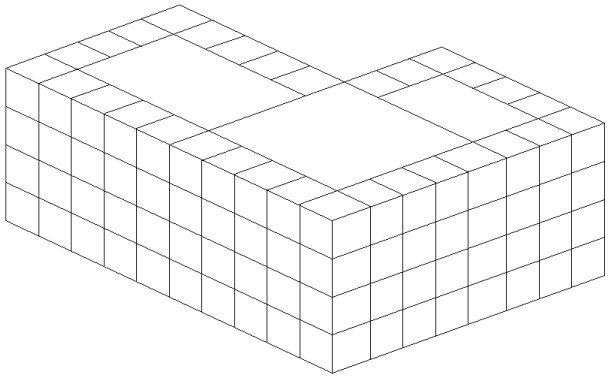
Total Blocks for Building = _____

4-Story Office

34 designed zones per floor.

136 zones total

Floor-by-floor VAV AHUs



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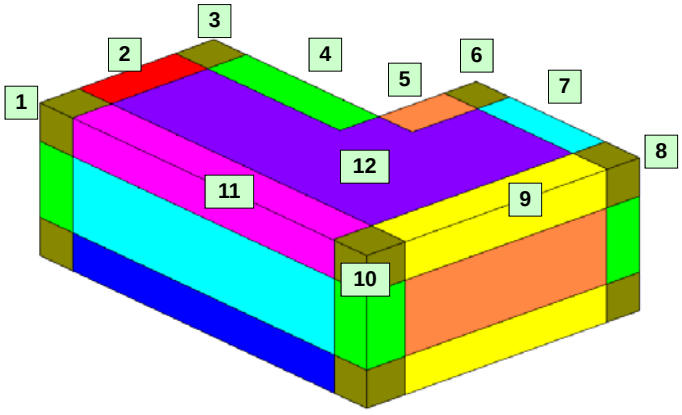
QUESTION #4 (CONTINUED)

"Good Answer"

Minimum Blocks per Floor = **12**

Total Blocks for Building = **3 x 12 = 36**



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FINISH MODELING PLAN FOR PROPOSED BUILDING

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. **Finish modeling plan for Proposed Building**
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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PROPOSED BUILDING MODEL

Finishing the Modeling Plan

Proposed Building Model

Start with actual design
Make allowed simplifications
Make required modifications

Approach

Assemble and review modeling checklist for Proposed Building

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PROPOSED BUILDING MODEL

Finishing the Modeling Plan

Sample Checklist

Illustrates checklist concept and application.
For New Construction scenarios only.
Includes key details; omits others due to space limitations.

Elements

General modeling issues
Schedules
Envelope
Lighting
HVAC Systems
Service Hot Water
Receptacle
Energy Prices

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PROPOSED BUILDING MODEL

(1) General Modeling Issues

✓	Item	Notes
✓	Scope of model	Simplification
✓	Space use classification	
✓	Thermal blocks	Simplification
	Consistent with design documents	
	Include all end uses for energy	

(2) Schedules

✓	Item	Notes
	Known: Use actual	
	Not Known: Use typical (90.1 User's Manual App G)	
	HVAC Fans - Run continuously occupied; cycle unoccupied	Not Actual

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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PROPOSED BUILDING MODEL

(3) Envelope

✓	Item	Notes
	Model wall, roof, floors, fenestration assemblies as designed	
	Uninsulated assemblies Simplified model flush with wall, or weighted avg U-value.	Simplification
	Assembly < 5% total area for assembly type. Include in larger assembly type, if thermally similar.	Simplification
	Azimuth or tilt within 45° - model as same orientation	Simplification
	Exterior Roof Reflectivity = 0.45 if (ρ > 0.70 and ε > 0.75) OR (SRI >= 82) Reflectivity = 0.30 otherwise	Not Actual
	Manually operated fenestration shading - Exclude	Not Actual
	Automatically operated fenestration shading - May Include	
	Permanent shading devices (e.g. fins, overhangs) - May include	

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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PROPOSED BUILDING MODEL

(4) Lighting

✓	Item	Notes
	System Designed - Use designed lighting power (per 9.1.3, 9.1.4)	
	System Not Designed - Define per Building Area Method	
	Portable lighting (e.g. task, furniture-mounted) - must include.	
	Exempt lighting (e.g. theatrical lighting) - must include.	
	Exterior lighting (e.g. façade, parking) - must include.	
	Automatic daylighting controls - may include. *via direct modeling or adjusted schedules*	
	Controls exceeding Mandatory provisions - may take credit *via reduced LPD or adjusted schedules* *Applies to programmable timing control and/or occ. sensors*	

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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PROPOSED BUILDING MODEL

(5) HVAC Systems

✓	Item	Notes
	System Designed - Model consistent with documents	
	No Heating System Designed: *Add heating. Use electric heat and baseline system type*	Not Actual
	No Cooling System Designed: *Add cooling. Use baseline system type*	Not Actual
	HW and CW Plants - Do not model pipe heat gain or loss	Not Actual

(6) Service Hot Water

✓	Item	Notes
	SHW Designed - Model as designed	
	SHW Not Designed - Model per baseline rules.	
	No SHW Loads Exist - Do not model SHW	

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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PROPOSED BUILDING MODEL

(7) Receptacle and Process Loads

✓	Item	Notes
	Receptacle and process loads - Must include.	
	Loads Known - Use actual data.	
	Loads Not Known - May estimate. *Resource: Table G-B in 90.1 User's Manual.*	

(8) Energy Prices

✓	Item	Notes
	Simple Approach - Use EIA flat prices (by state) *Energy Information Administration: www.eia.doe.gov*	
	Detailed Approach - Use actual utility rate structures	
	Must use one approach for all energy and fuels	

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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CREATE MODELING PLAN FOR BASELINE BUILDING

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. **Create modeling plan for Baseline Building**
7. Survey the competition
8. Execute analysis

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BASELINE BUILDING MODEL

Creating the Baseline Modeling Plan

Baseline Building Model

Start with proposed building model
Preserve elements which must be identical
Replace elements which must be prescriptive

Approach

Assemble and review modeling checklist for Baseline Building

Sample Checklist

Illustrates checklist concept and application
For new construction scenarios only
Includes key details; omits others due to space limitations

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PROPOSED BUILDING MODEL

Baseline Modeling Rules

Overview

Category	General Approach
1. Basic size, shape, usage.	
2. Envelope - Opaque Elements	
3. Envelope – Fenestration	
4. Lighting	
5. Service Hot Water	
6. HVAC Systems	

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BASELINE BUILDING MODEL

(1) General Modeling Issues

✓	Item	Same as Proposed	Prescriptive	Rule
	Scope	X		
	Space use classifications	X		
	Thermal blocks	X		
	Number of floors	X		
	Conditioned floor area	X		
	Temperature, humidity setpoints	X		
	Receptacle and process loads	X		
	Schedules (exceptions for lighting controls and DCV)	X		
	Simulation program	X		
	Weather data	X		
	Energy prices	X		

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(2) Envelope – Opaque Elements

✓	Item	Same as Proposed	Prescriptive	Rule
	General			
	Surface dimensions, orientation, tilt	X		
	Roof reflectivity			Fixed at ρ=0.30
	Self-shading			Do not model
	Envelope Assemblies			
	Above grade exterior walls		X	Steel framed
	Roofs		X	Insulation above deck
	Floors		X	Steel joist
	Slab on Grade		X	
	Opaque doors	X		

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(3) Envelope – Fenestration

✓	Item	Same as Proposed	Prescriptive	Rule
	General			
	Fenestration dimensions, orientation, tilt	X		
	Above Grade Walls - Window-to-Wall Ratio (WWR)	X	X	Smaller of Proposed or 40%
	Skylight-to-Roof Ratio (SRR)	X	X	Smaller of Proposed or 5%
	U-value and SHGC		X	
	Self-shading			Do not model
	Vertical Fenestration			
	Recesses, reveals			Do not model
	Permanent shading projections (e.g., fins, overhangs)			Do not model
	Interior shades (blinds, drapes, shades)			Do not model

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(4) Lighting

✓	Item	Same as Proposed	Prescriptive	Rule
	Space or building use classifications	X		
	Lighting power density		X	
	Schedules	X		Reflect mandatory control requirements

(5) Service Hot Water

✓	Item	Same as Proposed	Prescriptive	Rule
	Energy source	X		
	SHW is designed.		X	per 7.4.1, 7.4.2
	SHW not designed but will exist.		X	Electric, per 7.4.2

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(6) HVAC Systems

Procedure

1. Determine baseline system type based on proposed building type and size, and heating type (G3.1.1)
2. Apply general system requirements (G3.1.2)
3. Apply system-specific requirements (G3.1.3)

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(6) HVAC Systems – System Determination

	Fossil Fuel, Fossil/ Electric Hybrid, and Purchased Heat	Electric and Other
Residential	System 1 – PTAC	System 2 – PTHP
Non-Residential 1 to 3 floors AND < 25,000 ft²	System 3 – PSZ-AC	System 4 – PSZ-HP
Non-Residential [4 or 5 floors and < 25,000 ft²] OR [1 to 5 floors & 25,000 ft² to 150,000 ft²]	System 5 – Packaged VAV w/Reheat	System 6 – Packaged VAV w/PFPMBX
Non-Residential >5 floors OR >150,000 ft²	System 7 – VAV w/Reheat	System 8 – VAV w/PFPMBX

Data applies to New Construction scenario only. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(6) HVAC Systems – Baseline Systems

#	System Type	Fan Control	Cooling Type	Heating Type	Configuration
1	Pkg Terminal AC	CAV	DX	HW fossil fuel boiler	1 per zone
2	Pkg Terminal Heat Pump	CAV	DX	Electric heat pump	1 per zone
3	Pkg Rooftop AC	CAV	DX	Fossil fuel furnace	1 per zone
4	Pkg Rooftop Heat Pump	CAV	DX	Electric heat pump	1 per zone
5	Pkg Rooftop VAV w/Reheat	VAV	DX	HW fossil fuel boiler	1 per floor
6	Pkg Rooftop VAV w/PFPMBX	VAV	DX	Electric resistance	1 per floor
7	VAV AHU w/Reheat	VAV	Chilled Water	HW fossil fuel boiler	1 per floor
8	VAV AHU w/PFPMBX	VAV	Chilled Water	Electric resistance	1 per floor

Data applies to New Construction scenario only. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(6) HVAC Systems – General System Requirements

✓	Item	Rules
	HVAC equipment efficiency	Mandatory minimum efficiency per Section 6
	Cooling equipment capacity	Calculated peak load +15%
	Heating equipment capacity	Calculated peak load +25%
	Outdoor air economizer	Specific rules for inclusion and high limit shutoff
	Supply CFM sizing	Larger of CFM from 20° F ΔT or ventilation airflow.
	Minimum outdoor ventilation airflow	Must match Proposed (DCV exception)
	System fan power	Calculate per Baseline Fan Power Allowance procedure (G3.1.2.9)
	Exhaust air recovery	Specific rules for inclusion, eqpt efficiency
	Unmet load hours	Proposed and Baseline both =< 300 hrs Proposed cannot exceed Baseline by > 50 hrs

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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BASELINE BUILDING MODEL

(6) HVAC Systems – System-Specific Requirements

✓	Item	Rules Specify
	Air source heat pumps	Electric auxiliary; auxiliary not allowed >40° F
	Hot water boiler plants	Plant configuration, control, pump performance.
	Chilled water plants	Plant configuration, control, performance of pumps, cooling towers and cooling tower fans.
	VAV supply fan	VFD, part load performance
	VAV supply air	Supply temperature control for cooling.
	VAV air terminals	Minimum airflow settings

Sample checklists apply to New Construction scenario only and include key issues. Refer to 90.1 Appendix G for full requirements

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SURVEY THE COMPETITION

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. **Survey the competition**
8. Execute analysis

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SURVEYING THE COMPETITION

Basic Principles

Concepts

Proposed competes with Baseline

Differentiation between Proposed and Baseline –
Qualifies Proposed as high performance and earns LEED® points

Survey differences, assess potential before assembling the models

Outcomes

Go – Good potential for savings and points exists; proceed

No-Go – Poor potential; reconsider design or look elsewhere for pts

Areas of Focus

Envelope – Walls, Roofs, Floors

Envelope – Fenestration

Lighting

HVAC

SHW

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SURVEYING THE COMPETITION

Example #1

Single story office building
23,000 sqft conditioned floor area
Kansas City, MO (Climate Zone 4A)

Category	Proposed	Baseline	Differentiation
Envelope - Walls	Mass Wall		
	U = 0.055, R-14 c.i.		
Envelope - Roof	Built-up roof, insul above steel deck		
	U = 0.047, R-20 c.i.		
Envelope - Floor	Unheated slab, F = 0.690		
Envelope - Fenestration	WWR = 20%		
	U = 0.50, SHGC = 0.39		
Lighting - Interior	1.0 W/sqft		
HVAC System	Single Zone CAV, ASHP		
	Electric auxiliary heat		
	11.1 EER, 3.3 COP		
	16.5 EER, 3.4 COP	11.0 EER, 3.3 COP	

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SURVEYING THE COMPETITION

Example #2

Single story office building
23,000 sqft conditioned floor area
Kansas City, MO (Climate Zone 4A)

Category	Proposed	Baseline	Differentiation
Envelope - Walls	Mass Wall	Steel Framed Wall	
	U = 0.040, R-21 c.i.	U = 0.064, R-13 and R-7.5 c.i.	
Envelope - Roof	Built-up roof, insul above steel deck	Insulation above deck	
	U = 0.032, R-30 c.i.	U = 0.048, R-20 c.i.	
Envelope - Floor	Unheated slab, F = 0.690	Unheated slab, F = 0.730	
Envelope - Fenestration	WWR = 20%	WWR = 20%	
	U = 0.40, SHGC = 0.29	U = 0.55, SHGC = 0.40	
Lighting - Interior	1.0 W/sqft	1.0 W/sqft, Building Area Method	
	w/ Roof Monitors + Daylight Control		
HVAC System	Ground Source Heat Pumps	System 4 - PSZ-HP	
	Gas Boiler Auxiliary Heat	Electric auxiliary heat	
	16.5 EER, 3.4 COP	11.0 EER, 3.3 COP	

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EXECUTE ANALYSIS

Plan-Then-Execute Method

1. Choose software
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. **Execute analysis**

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PLAN-THEN-EXECUTE METHOD

Plan-Then-Execute Method

1. **Choose software (revisited)**
2. Determine scope for energy modeling
3. Determine space classifications
4. Determine thermal block strategy
5. Finish modeling plan for Proposed Building
6. Create modeling plan for Baseline Building
7. Survey the competition
8. Execute analysis

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SOFTWARE SELECTION REVISITED

Key Conditions for High Quality Modeling

1. **The Energy Modeling Tool**
   Appropriate, robust tool matched to objectives
2. **The Energy Modeler**

Proficient with:

HVAC engineering fundamentals

Chosen energy modeling software

Procedure required to achieve objective

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SOFTWARE SELECTION REVISITED

Key Conditions for Efficient Modeling

1. **The Energy Modeling Tool**
   Provides features to automate PRM-related tasks
2. **The Energy Modeler**
   Uses efficient approach (e.g. Plan-Then-Execute)

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SOFTWARE SELECTION REVISITED

Challenges for Efficient Modeling

The Problem

Rating procedures require specialized tasks

Outside normal scope of energy modeling

Tasks can be labor intensive

Proposed Solution

Automation of key PRM tasks

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SOFTWARE SELECTION REVISITED

Sample High Impact Tasks for Automation

Inputs

1. Copying entire Proposed Building as basis for Baseline
2. Efficiently converting data to prescriptive – assemblies, lighting, systems
3. Rotating baseline building

Calculations

1. Setting equipment capacity based on 15% and 25% factors
2. Setting equipment efficiency per ASHRAE 90.1 minimums
3. Decompiling EERs and COPs into compressor and fan components
4. Performing baseline fan power allowance calculation (G3.1.2.9)
5. Setting PFPMBX fan power based on W/CFM specification
6. Setting CW, Cond Water, HW pump power based on W/gpm specification

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SESSION OBJECTIVES

After this session you should be able to:

1. Identify the key prerequisites for high quality energy modeling and the risks created by failing to meet each prerequisite
2. Explain how the ASHRAE 90.1 Appendix G Performance Rating Method determines energy cost savings for a building project, and how the cost savings are used to calculate LEED® Energy and Atmosphere Credit 1 points
3. State the basic principles used to assemble the Baseline Building for a given proposed Design in a LEED® Energy and Atmosphere Credit 1 analysis
4. Describe how to evaluate thermal block modeling issues in a building to minimize modeling cost and at the same time preserve accuracy of results

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ENERGY MODELING FOR LEED®

QUESTIONS?

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